Logging Residues on Harvesting Operations, Western South Dakota, Wyoming, Utah, and Colorado

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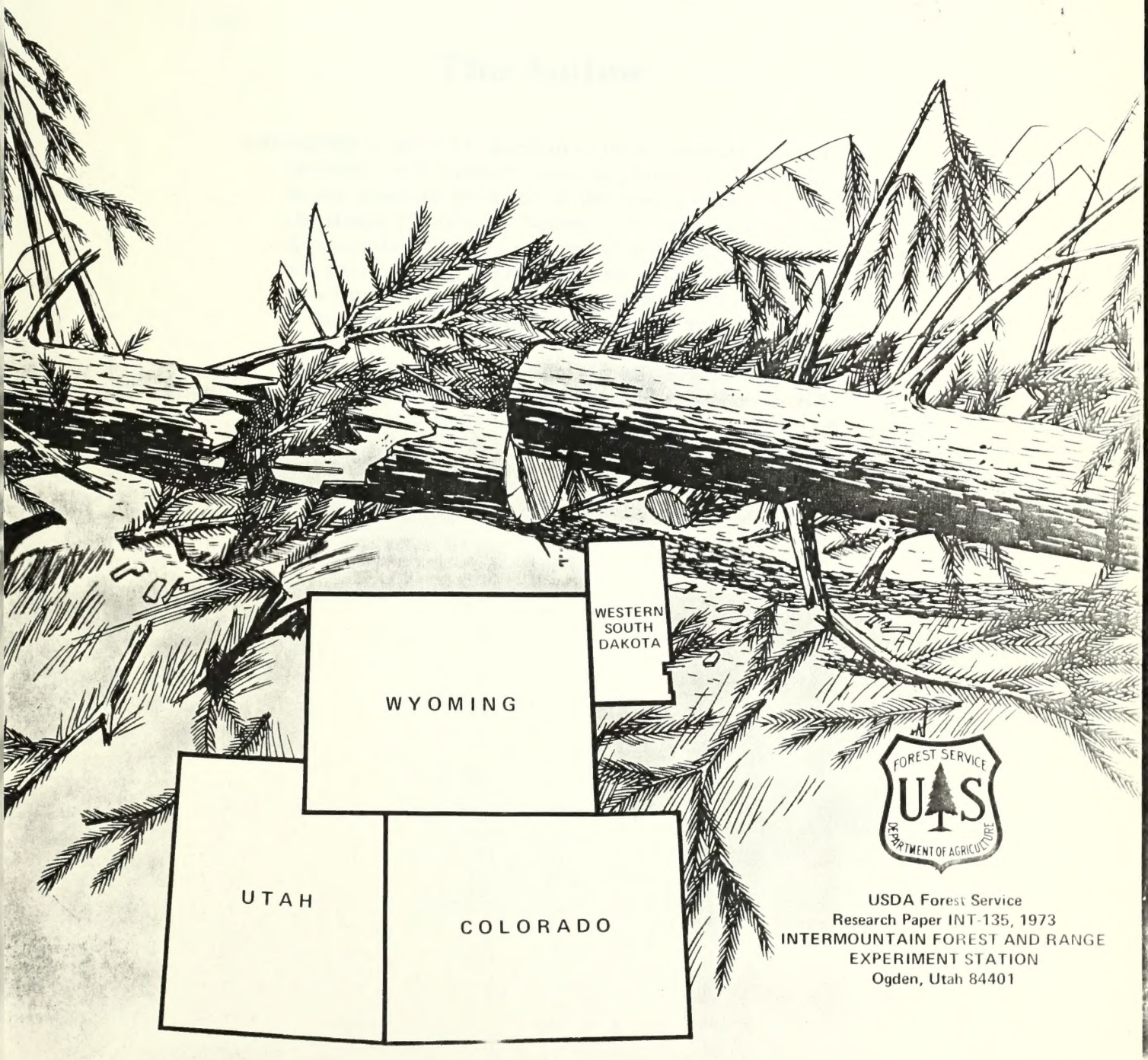

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INTERMOUNTAIN FOREST AND RANGE
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Contents

Abstract

Reports results of studies made of timber harvesting operations in western South Dakota, Wyoming, Utah, and Colorado to estimate volumes of logging residues. Shown are: factors that can be applied to product volumes to estimate total removals from inventory; residue volumes as percentages of saw log volumes; estimates of cubic-foot and board-foot volumes of logging residues for 1969; estimates of cubic-foot volumes of residues to a 4-inch top in pieces 6 feet and longer; the relative importance of felling and skidding as causes of residues; and the numbers of trees removed from growing stock inventories by harvesting. Survey methods and reliability of data are discussed.

Introduction

The reduction in inventory resulting from a timber harvesting operation is of vital concern to land managers. Product removal figures are relatively easy to obtain for a particular operation, but such figures do not adequately represent the total removals; therefore, the residual stand may be overestimated. The unused volume of timber cut or killed during timber harvesting operations and left in the woods represents an additional reduction in the inventory of volume available for future planning, management, and harvesting. It is a factor to be considered in reconciling differences in the estimates of volume of standing timber between successive inventories. Also, timberland managers are interested in estimates of residue material that could be chipped if there were a market, or would have to be dealt with in protecting and managing the forest.

Logging residues studies are conducted by the Forest Survey research work unit of the Intermountain Forest and Range Experiment Station for the purpose of estimating net inventory loss from timber harvesting operations. Since 1965, logging residues studies have been conducted in seven Rocky Mountain States and in South Dakota west of the 103d meridian. (The 103d meridian is used in South Dakota as a demarcation line between the western forests and the relatively insignificant eastern forests.)

The purpose of this paper is to show the results of residues studies conducted in South Dakota west of the 103d meridian, Wyoming, Utah, and Colorado in 1969. Presented are (a) factors to apply to net product volume to estimate total net removals from inventory (b) net volumes of logging residues from saw log operations as percentages of net product volume; (c) estimates of cubic-foot and board-foot volumes of logging residues for 1969 (fig. 1); (d) estimates of cubic-foot volumes of residues to a 4-inch top in pieces 6 feet and longer; and (e) estimates of numbers of growing stock trees removed from inventory during saw log operations per thousand cubic feet (MCF) of net product volume, by diameter at breast height (d.b.h.) classes.

Figure 1.--Logging residues resulting from breakage in felling a sawtimber tree. In this example the entire portion of the tree above the shown cut, containing both board-foot and cubic-foot volumes, was left in the woods.

Factors for Determining Residual Inventory

Product removal figures are relatively easy to obtain for a particular harvesting operation, but such figures do not adequately represent the total removals and, therefore, initial inventory less products removed does not equal the residual stand. An adequate calculation of the remaining inventory after logging can be done only by subtracting total removals (including product volume plus residues from felling and skidding) from the prelogging inventory.

It is important that removal volume consists only of volume included in the inventory and not amounts overutilized according to Forest Survey standards. Overutilized material can come from (a) harvesting saw logs from growing stock trees of less than sawtimber size (from trees less than 9 inches d.b.h.); (b) utilizing wood below the Survey standard 1-foot stump; (c) wood from treetops above top diameters specified in the timber inventory; or (d) nongrowing stock trees by Survey standards.

In computing removal factors (table 1) for applying to product output estimates in order to arrive at total removals, net overutilized material (by Forest Survey standards) has been excluded from the total net removal volume measured. However, in developing these factors, the net overutilized volume must be included in the net product volume because it is part of the reported product output volume to which factors will be applied. Therefore, removal factor = $\frac{\text{removal volume}}{\text{product volume}}$. This is equivalent to $\frac{\text{net product volume (excluding overutilization)} + \text{net residue volume}}{\text{net product volume (including overutilization)}}$

In the four States, the net volume in cubic feet of timber removed from growing stock inventory in harvesting operations is more than the cubic-foot volume of saw logs harvested. In other words, the ratio of cubic feet of inventory removed (including residues) to cubic volume of saw logs harvested is greater than one. On the other hand, factors based on board-foot[1] volumes to estimate removals from sawtimber inventory are somewhat less than those for cubic feet used for growing stock estimates because considerable wood measured as net cubic-feet residue is not included

[1]Board-foot volumes used in this paper are based on the International 1/4-inch log rule.

Table 1.--*Removal factors by Forest Survey standards to estimate total net removals from inventory, western South Dakota, Wyoming, Utah, and Colorado*

Unit of measurement and minimum top diameter	South Dakota	Wyoming	Utah	Colorado
Cubic foot 4 inches	[1]1.038	1.070	1.068	1.100
Board foot variable	.997	.933	.974	1.035
Board foot 7 inches	.984	.929	.973	1.035

[1] For example: 1.038 × 7,352 MCF of saw logs harvested in western South Dakota in 1969 = 7,631 MCF total net removals by Forest Survey standards.

in the net board-foot scale. This wood is (a) in the upper stem portion beyond the minimum top diameter for board-foot measure; (b) in destroyed growing stock trees of less than sawtimber size; and (c) in portions of trees suitable for production of fiber but is cull for saw logs because of crook.

Board-foot measurements to the minimum variable top used by Forest Survey do not result in factors much different from those resulting from the minimum fixed top of 7 inches.

Logging Residues as a Percent of Product Volume

The net volume of logging residues represents underutilization. By Forest Survey's cubic-foot standards, residues include all unused net volume between a 1-foot stump and a 4-inch minimum top diameter inside bark (d.i.b.). By board-foot standards, net residues volume includes unused wood in sawtimber trees between a 1-foot stump to either variable or fixed top diameter (fig. 2). Also included in sawtimber residues are merchantable logs missed in skidding.

Most of the residue volume is caused by felling and is wood from the trees from which saw logs are harvested. Skidding losses are relatively minor and, as shown in table 2, amount to less than 25 percent of the cubic-foot residue volume in each of the four States.

The net volume of logging residues resulting from harvesting a reported volume of saw logs can be estimated using the percentages in table 3; the figures in this table are not adjusted for overutilization. Their use provides an estimate of actual residues (table 4) without the partial compensation of overutilization volumes, such as can be obtained by using table 1 factors. Residue volumes derived using the percentages in table 3 should not, of course, be considered as a measure of economically available chippable wood. The study was not designed to provide this information.

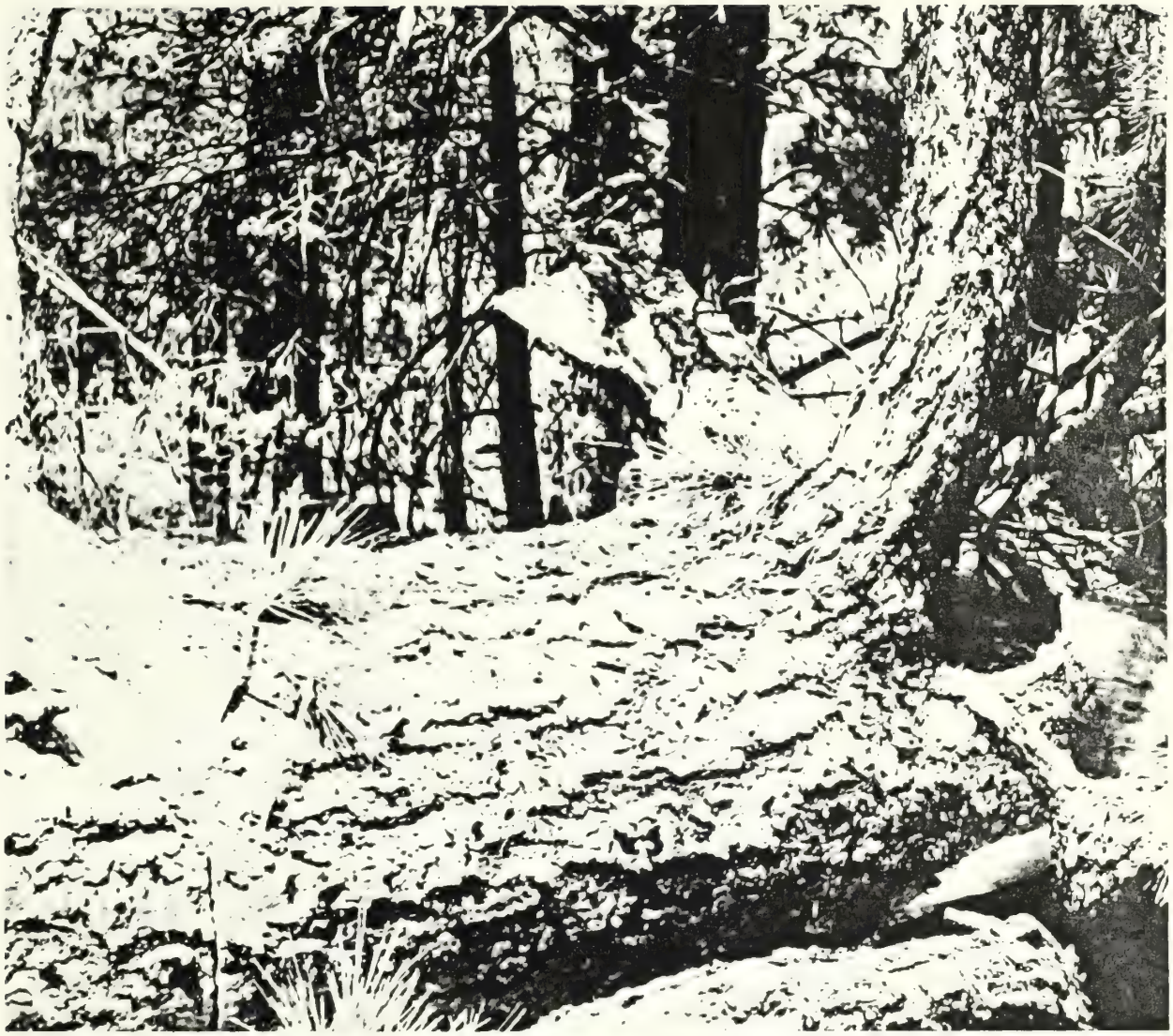

Figure 2.--Cutouts, such as the one shown, in the saw log portions of product trees can result in board-foot and cubic-foot volumes. In this case, the log was bucked to the right of a large limb leaving as residue a clear, 2-foot length. This indicates bucking for a particular length rather than for quantity of usable wood.

Table 2.--*Logging residues produced by felling and skidding*

State	Felling			Skidding	Total
	Product trees	Other[1] trees	All trees		
	Percent				
Western South Dakota	71.33	5.02	76.35	23.65	100.00
Wyoming	70.75	4.99	75.74	24.26	100.00
Utah	90.40	7.95	98.35	1.65	100.00
Colorado	79.52	11.22	90.74	9.26	100.00

[1] Trees not specifically intended for removal.

Table 3.--*Net volume of logging residues from saw log operations as a percent of net product volume*

Unit of measurement and minimum top diameter	Western South Dakota	Wyoming	Utah	Colorado
Cubic foot 4 inches	[1]4.72	7.68	7.31	10.43
Board foot variable	.98	1.93	2.61	4.51
Board foot 7 inches	.91	1.73	2.61	4.44

[1] For example, 0.0472 × 7,352 MCF of saw logs harvested in western South Dakota in 1969 = 347 MCF of logging residue (not adjusted to Forest Survey standards).

Table 4.--*Calculated estimates of logging residues, by States, for 1969*

State	Volume of saw logs from growing stock, 1969[1] (A)	Cubic foot residues[2] (B)	Volume of logging residue (A×B)
	M cubic feet	*Percent*	*M cubic feet*
Western South Dakota	7,352	4.72	347
Wyoming	28,701	7.68	2,201
Utah	11,210	7.31	819
Colorado	34,792	10.43	3,629

[1]Based on the 1969 Products Output Study conducted by the Forest Survey research work unit at the Intermountain Forest and Range Experiment Station, Ogden, Utah.
[2]From table 3.

Table 5.--*Estimates of logging residues to a 4-inch top, in pieces 6 feet and longer, 1969*

State	Volume	Number of trees measured with sound residue 6 feet and longer (A)	Total number of trees measured (B)	(A)/(B)
	MCF			*Percent*
Western South Dakota	226.13	100	211	47
Wyoming	1,353.85	109	161	68
Utah	637.69	71	82	87
Colorado	2,115.95	257	286	90

Residue Volumes in Pieces 6 Feet and Longer

Estimates of the cubic-foot volumes of logging residues to a 4-inch top are presented in table 5. The estimates were developed according to the following procedures.

All product trees except aspen which were part of the logging residue samples were measured in place and after bucking from the last cut made for products to a 4-inch top. Net volumes were calculated and totaled only for sound pieces (no rot present) 6 feet and longer, for each State. The total of these volumes was then expressed as a percent of the total net product volume sampled for each State, and this percent was applied to the total volume of saw logs harvested in 1969. The resulting estimates represent rot-free residues. Additional residue volume is often available in the form of trees damaged by felling and skidding but left in the woods either standing or down.

The number of product trees having sound pieces of unused wood 6 feet and longer, when compared to the total number of product trees measured, may be indicative of the degree of utilization. When these comparisons are expressed as percentages, they range from 47 percent in South Dakota to 90 percent in Colorado; this suggests that utilization in South Dakota is better than in Colorado.

Diameter Class Distribution of Trees Harvested or Destroyed

Information on the number of growing stock trees harvested or destroyed (and, therefore, removed from inventory) by diameter class is essential for computing the diameter class cutting rates used in most stand-table projections of growth and inventory (fig. 3). Reliable data of this kind are usually difficult to obtain. However, these studies provide an estimate of the distribution of trees removed in relation to volume of saw logs harvested. Table 6 shows the total number of growing stock trees (product trees and other) removed per 1 MCF of product volume.

Figure 3.--Usually the largest numbers of growing stock trees destroyed during harvesting are in the smaller diameter classes.

Table 6.--*Growing stock trees removed from inventory in saw log operations per MCF of net product volume*

D.b.h. class (inches)	Western South Dakota	Wyoming	Utah	Colorado
	Number of trees			
2	33.2939	15.3177	2.4207	8.6973
4	18.5905	10.9661	3.3890	8.1218
6	4.3941	3.6554	1.6945	2.6859
8	6.9292	3.4813	1.2104	2.7499
10	5.4081	4.6997	1.2104	2.9417
12	6.2532	7.1366	4.1152	2.3662
14	7.2672	11.4882	2.4207	3.3254
16	4.7321	2.6110	3.1469	2.0464
18	3.2111	2.2628	3.1469	2.2383
20	1.6900	.8703	1.4524	1.5348
22	.6760	.1741	1.6945	.7674
24	--	.5222	.4841	.7674
26	--	.1741	--	.7035
28	--	.5222	--	.4477
30+	.1690	.5222	1.9366	.8953
All classes	92.6144	64.4039	28.3223	40.2890

Study Methods and Reliability of Estimates

Study design prescribed three basic measurements of growing stock trees on active logging operations:

1. Net volume of saw logs harvested from product trees measured on a logging operation.

2. Net volume of residues from the same trees.

3. Net volume of residues from trees cut or damaged as a result of felling and skidding product trees.

These measurements were related in compilation to determine volume of residues as a percent of saw log volume. Measurements provided both gross and net cubic-foot volumes for all measured growing stock trees. Careful scaling provided gross and net board-foot volumes to fixed and variable tops for measured sawtimber trees. Species, d.b.h., total height, overutilization (by Forest Survey standards), and whether residues resulted from felling or skidding were also recorded.

The number of basic sample units used in the study corresponded to the number of logging operations on which measurements were taken. The number of samples for each State shown in the following tabulation were drawn from a list of active logging operations in each State.

State	*Number of operations*
Western South Dakota	12
Wyoming	9
Utah	4
Colorado	19
	44

To assure unbiased estimates and good distribution, the samples were drawn at random within strata defined by land ownership and operator size class. Two ownership classes were used--National Forest and other. Operator size class corresponded to the production class of the sawmill for which the logging was being done. Two size classes were used--small (less than 10 million board feet per year) and large (10 million board feet and more).

Past experience in Idaho, Montana, Arizona, and New Mexico indicated that about 44 samples distributed as shown in the tabulation on page 10 should result in estimates of standard errors of the means of cubic residue volumes of about 20 percent per State and for western South Dakota.

The actual sample sizes used and standard errors achieved are shown in table 7. The cubic-foot standard errors are the most meaningful to Forest Survey because survey standards are expressed in cubic volumes. In the four States the variability encountered was greater than anticipated and the resulting standard errors are higher than expected. In Utah the standard error is especially high but because the residue volume in the State is small, the error appears acceptable.

Trees felled for products were measured where they had been felled to determine both product and residue volumes. Residue volume from other trees damaged or cut as a result of felling product trees was also measured. Skidding damage to trees along skid trails was determined after logs reached the landing except in those cases where crews were on hand to witness damage as it occurred.

A slightly different procedure was used for clearcut operations where there was difficulty in relating felling and skidding damage to individual product trees. In these cases, product trees were those whose stumps fell within a circular plot. All product trees were measured within the plot and felling and skidding damage was assessed on the plot area.

Caution is recommended in applying estimates shown in this report to any State subdivisions. Important interrelated factors that contribute to variation in the amount of residues per unit of product volume from one area to another include stand conditions (size and soundness of trees, species, stocking, etc.); markets for various species, sizes, and qualities of timber; and logging costs and techniques as determined by accessibility, terrain, etc.

Table 7.--*Standard errors of ratios for logging residue volumes by net cubic- and board-foot measures*

Unit of measurement and minimum top diameters	Western South Dakota (14 samples)	Wyoming (12 samples)	Utah (6 samples)	Colorado (21 samples)
	Percent			
Cubic foot 4 inches	16.6	21.0	35.8	12.0
Board foot variable	29.7	21.5	47.1	21.0
Board foot 7 inches	32.4	24.2	45.3	21.7

Conclusions

Estimates of logging residues are important for several reasons. First of all, they express a reduction in inventory of the residual stand for which no economic return was gained. Second, unless logging residues are included with product volume, the estimate of residual stand volume with which the manager must work in the future is overstated. The consequences of planning future management with overstated estimates are obvious. Third, the volume of residues that might be salvaged for fiber production is of interest in areas where there is a market for chips. Logging operations that result in high underutilization of product material are, therefore, costly both now and in the future.

Appendix

Terminology

Cull trees.--Live trees of commercial species that will not now or in the future qualify as sawtimber trees because of dimensions, form, rot, or damage. Also includes all live trees of noncommercial species.

Cull volume --Portions of a tree that are unusable for industrial wood products, because of rot, form, or other defect.

Diameter classes.--A classification of trees based on diameter breast height (d.b.h.) outside bark. Two-inch diameter classes used by Forest Survey are identified by the diameter at the approximate midpoint of each class. For example, the 2-inch class includes trees 1.0 to 2.9 inches d.b.h.

Growing stock trees.--Live trees of commercial species except those that are cull because of form, rot, or other defect.

Growing stock volume.--Net volume in cubic feet of growing stock trees 5.0 inches d.b.h. and over from a 1-foot stump to a minimum 4.0-inch top diameter inside bark of the central stem or to the point where the central stem breaks into limbs.

Logging residues.--The unused portions of trees cut or killed by logging.

Net volume.--Gross volume less deductions for rot, sweep, or other defect affecting use for timber products.

Poletimber trees.--Growing stock trees likely to grow into merchantable sawtimber trees. They must not show evidence of rot in the main stem or have serious damage, crook, or stagnation. Softwoods must be from 5.0 to 8.9 inches d.b.h. and hardwoods from 5.0 to 10.9 inches.

Sawtimber trees.--Growing stock trees containing at least a 12-foot saw log with not *more than two-thirds of the gross* board-foot volume in cull material. Softwoods must be at least 9.0 inches d.b.h. and hardwoods at least 11.0 inches.

Sawtimber volume.--Net volume (in board feet International 1/4-inch log rule) of sawtimber trees between a 1-foot stump and a specified merchantable top--fixed or variable. A fixed top is 7 inches d.i.b. A variable top varies with d.b.h. as follows:

Range in d.b.h. *Inches*	*Top d.i.b.* *Inches*
9.0 - 10.9	5
11.0 - 14.9	6
15.0 - 18.9	7
19.0 - 20.9	8
21.0 - 24.9	9
25.0+	10

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Reports results of studies to estimate volumes of logging residues. Shown are: factors that can be applied to product volumes to estimate total removals from inventory; residue volumes as percentages of saw log volumes; estimates of cubic-foot and board-foot volumes of residues for 1969; estimates of cubic-foot volumes of residues to a 4-inch top in pieces 6 feet and longer; the relative importance of felling and skidding as causes of residues; and the numbers of trees removed from growing stock inventories by harvesting.

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